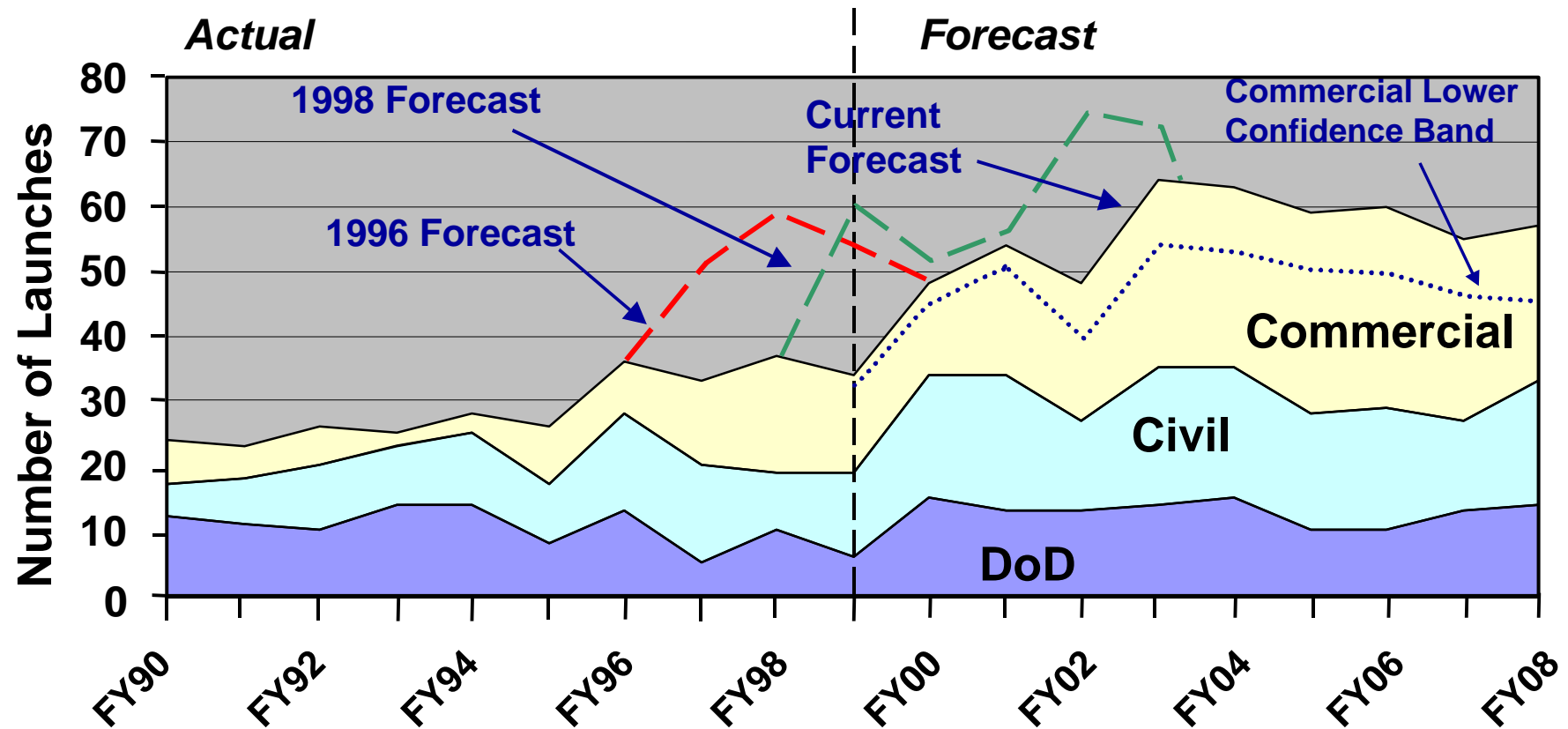


Launch History and Forecasts

Total U.S. Space Launches -- Quantity of Launches



Bow wave continues to shift to the right
Forecast indicates government will remain a prominent player

Sources: National Launch Forecast, Space Launch Manifest, NASA Forecast, SV and LV Contractor Manifests, Space Launch Information Center

Fly-out Context

- **Atlas, Delta and Titan launched 777 space missions since 1958**
- **Established national security satellite constellations for:**
 - *Communications*
 - *Missile early warning*
 - *Weather*
 - *Navigation*
 - *Reconnaissance and surveillance*
 - *Experimentation*
- **Provided the foundation for the U.S. commercial launch industry**
- **Contributed to NASA's space science and planetary missions and early manned space flight**

Failures & Serious Anomalies



- **Atlas/Delta/Titan launch vehicles**
 - *One failure per year (average) during past 12 years (200 launches)*
 - *Five failures (Delta III, Titan IV) in 10 months (25 launches)*
 - **Upper stages -- 3 failures (5 launches)**
- **Serious Atlas/Delta/Titan anomalies - e.g., major leak, bad separation, nozzle loss**
 - *18 in past 12 years (200 launches)*
 - *9 in 24 months (51 launches)*

Recent Failures



Government Missions

- Titan IV A-20/Centaur/NRO
 - *Titan wiring harness caused short -- damaged pre-launch*
- Titan IV B-27/Inertial Upper Stage-21/DSP-19
 - *IUS thermal tape misapplication restricted separation connector operation -- indications present in previous flights*
- Titan IV B-32/Centaur TC-14/Milstar-3
 - *Centaur manual data entry error in flight software -- resulting anomaly detected pre-launch but not corrected*

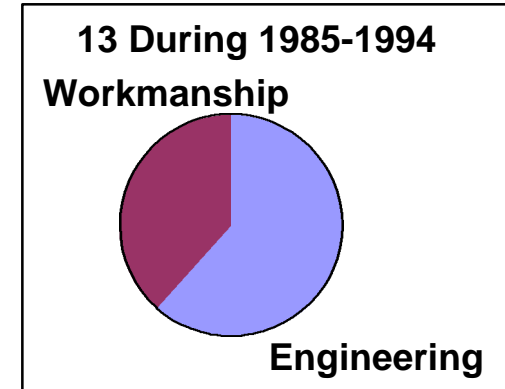
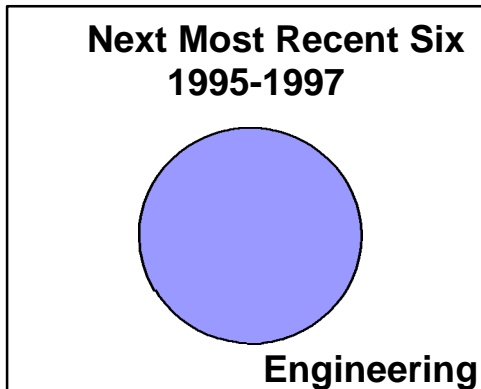
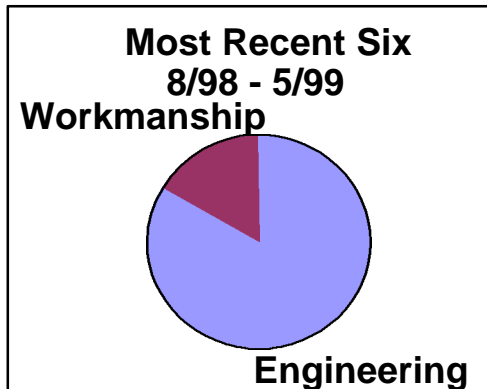
Commercial Missions

- Delta III 259/Galaxy-X
 - *Inadequate modeling of flight control dynamics*
- Delta III 269/Orion-3
 - *Inadequate brazing specification potentially coupled with vehicle induced loading caused combustion chamber breach*

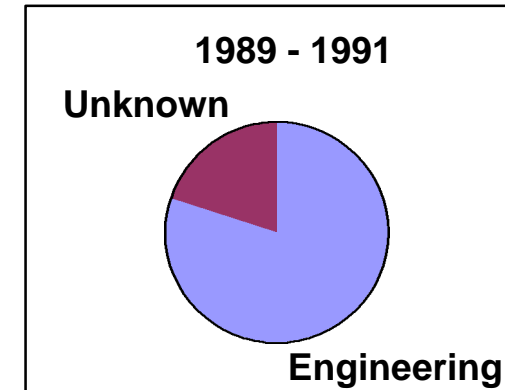
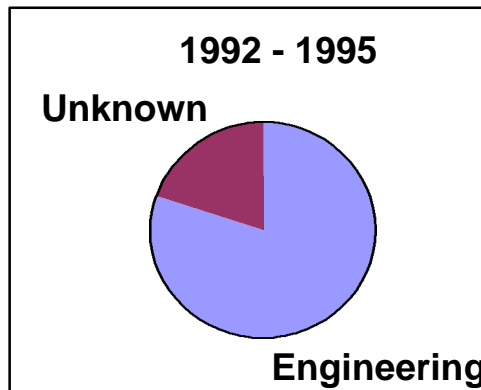
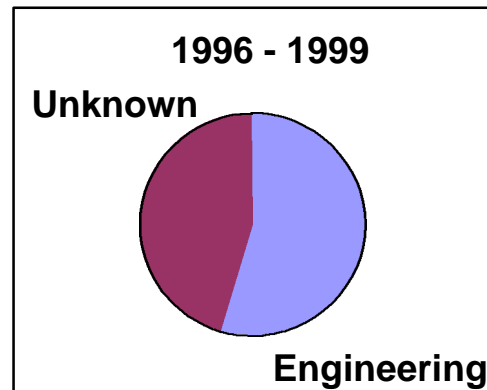
Factory-introduced engineering and workmanship errors predominate

Failure and Major Anomaly Causes

Failures -- 76% Engineering



Major Anomalies -- 69% Identifiable as Engineering



- **Engineering deficiencies prominent in majority of mishaps**
- Space launch remains an intensely engineering activity
- Inadequate post flight analysis of anomalies

Some Current Launch System Facts of Life



- **Titan IV system launches**
 - *Remaining 11 launches involve high value national security spacecraft (~\$9 Billion)*
 - *Are demanding -- will never be routine*
 - *Each configuration is unique*
 - *Almost no margin for error*
 - *Infrequent events -- e.g. Titan/IUS had 1 launch in 4 years (1994-1998)*
 - *Launch schedules inevitably move to the right -- often significantly*
- **Even Atlas and Delta, with a string of launch successes, generate continuing unique challenges**
 - *Atlas and Delta experienced 8 major anomalies in last 2.5 years*
 - *Atlas 141 has been on Pad 3E at Vandenberg for more than two years due to spacecraft and upper stage issues*

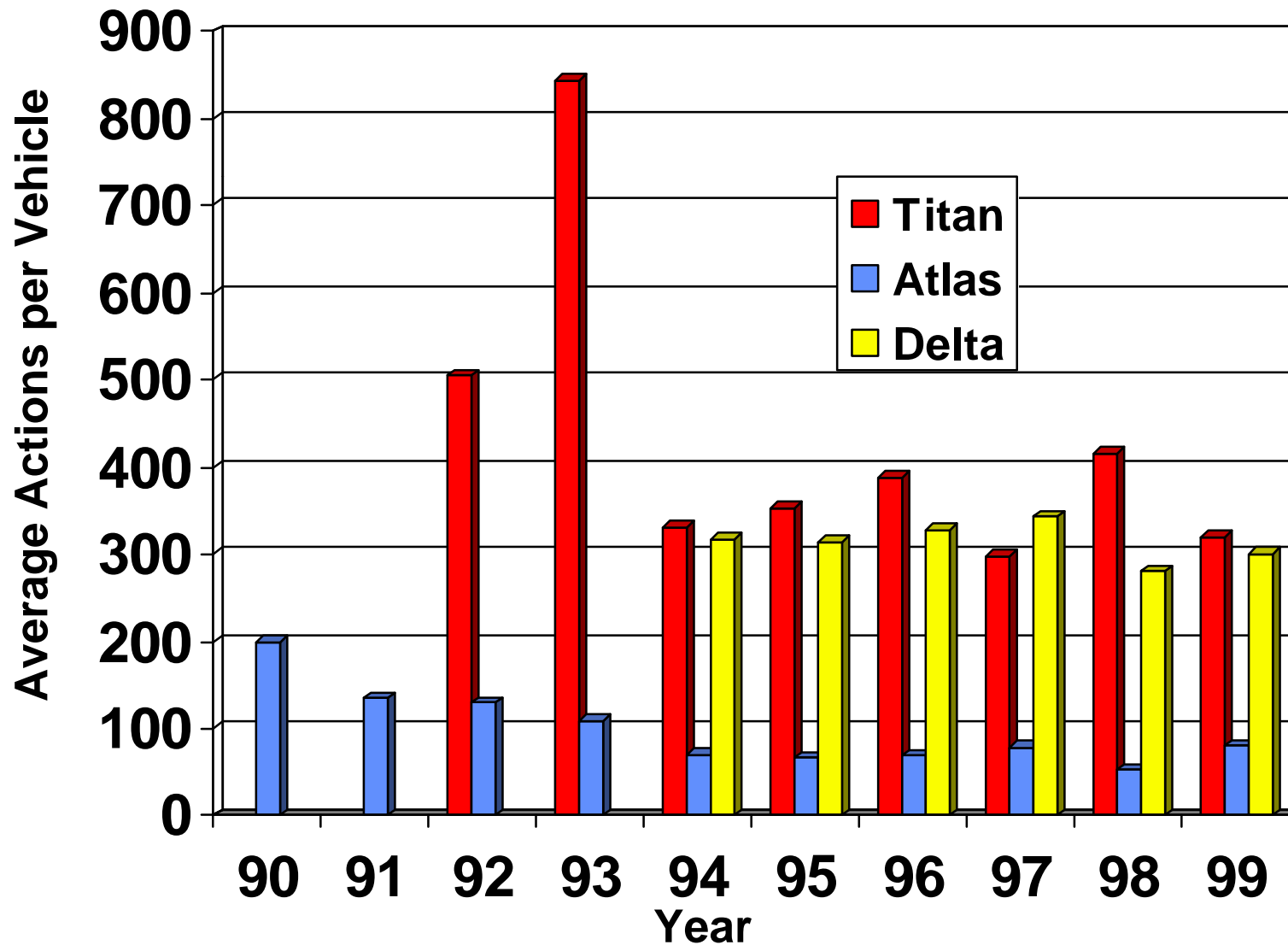
Titan Development

- **1960s -- Air Force started heavy lift space booster program using Titan II upgraded to Titan III**
- **1978 -- decision to fly all DoD, civil and commercial spacecraft on the Space Shuttle ended the Atlas, Delta and Titan 34D programs -- based on economics**
- **1983 -- Air Force initiated the CELV program to back up the space shuttle -- continue a Titan/Centaur line for 10 additional launches**
- **28 January 1986 -- Challenger accident**
 - *Unmanned missions to be on ELVs*
 - *The U.S. expendable fleet was reborn*
 - *Titan program redefined with multiple configurations & launch sites*
- **June 1989 -- first launch of the 41-buy Titan IV**

**Titan IV acquisition reflects emergency response to
accommodate spacecraft from Shuttle**

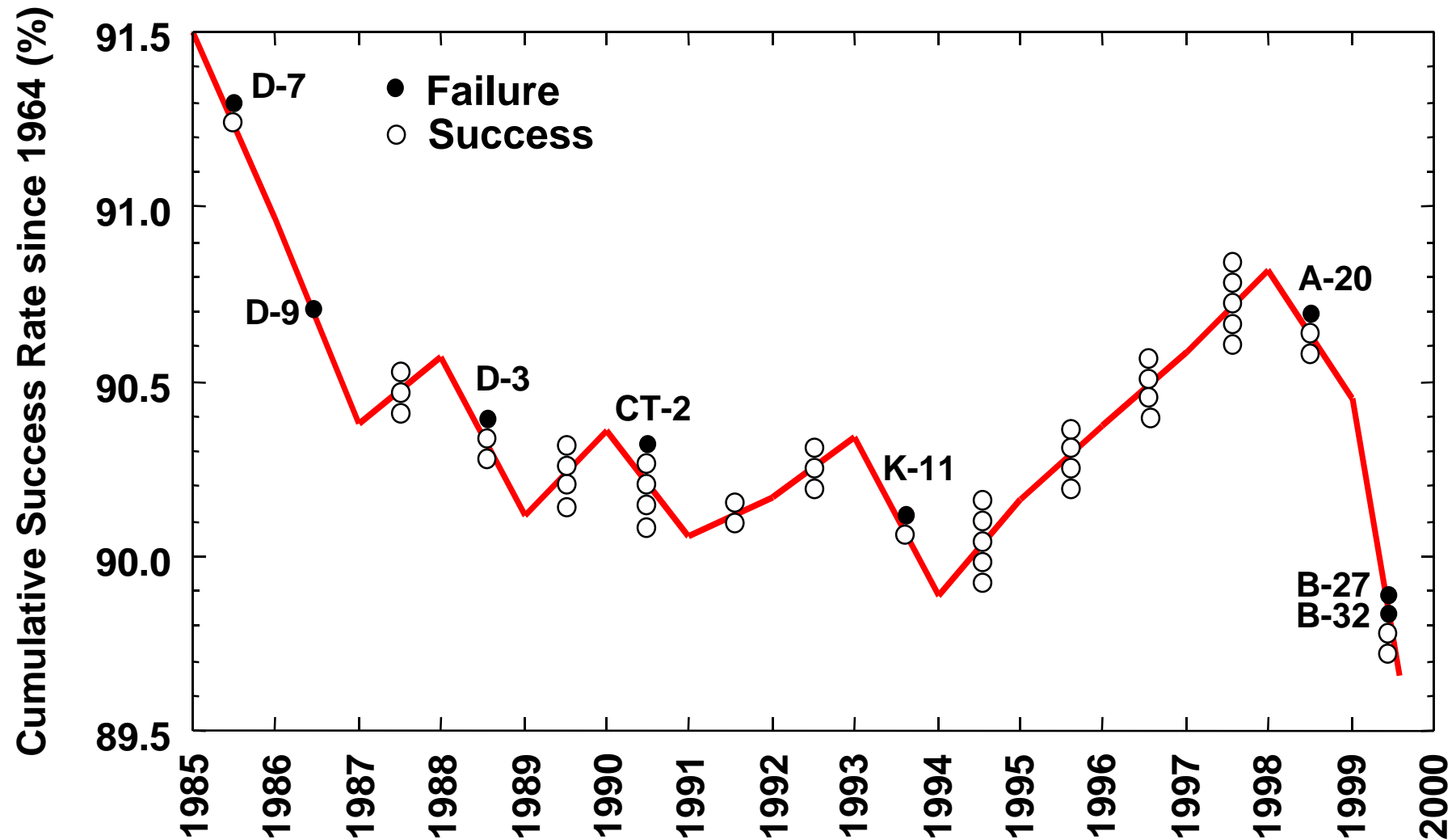
Manufacturing Discipline

Launch Base Unplanned Work



Ninety percent of unplanned Titan work to correct factory errors

Titan Success Rate History



Mission success planning needs to reflect launch reliability reality